

# Anirudh Singhal

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## RESEARCH INTERESTS

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Reinforcement Learning, Statistical Machine Learning, Online Learning, Applied Probability, Computer Vision

## EDUCATION

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### Indian Institute of Technology Bombay (IITB)

Jul'16-Present

Dual Degree (Bachelor + Master of Technology) in Electrical Engineering

Specialization: Communication and Signal Processing

**Major GPA:** 9.51/10 (4<sup>th</sup> among 70+ students)

Pursuing a Minor in Computer Science and Engineering; Minor GPA: 9.67/10

### Technical University of Denmark (DTU)

Aug'19-Dec'19

Selected to represent IIT Bombay as an Exchange Scholar to attend a semester at DTU; GPA: 12/12

## PUBLICATIONS & PATENTS

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Query Complexity of  $k$ -NN based Mode Estimation 

Publication

**Anirudh Singhal**<sup>†</sup>, Subham Pirojiwala<sup>†</sup> & Nikhil Karamchandani

Under review at 2020 IEEE Information Theory Workshop (ITW), April 2021, Riva del Garda, Italy

Towards a Unified Framework for Visual Compatibility Prediction 

Publication

**Anirudh Singhal**<sup>†</sup>, Ayush Chopra<sup>†</sup>, Kumar Ayush<sup>†</sup>, Utkarsh Patel<sup>†</sup> & K. Balaji

2020 IEEE Winter Conference on Applications of Computer Vision (WACV), March 2020, Colorado, USA

Deep Learning Based Visual Compatibility Prediction For Bundle Recommendations

Patent

**Anirudh Singhal**, Ayush Chopra, Kumar Ayush, Utkarsh Patel & K. Balaji

Filed in United States Patent and Trademark Office (USPTO) in May 2020; Patent Number : US 16/865,572

<sup>†</sup> equal contribution

## RESEARCH EXPERIENCE

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### Holistic Deep Learning based Solutions for Fashion Compatibility

May'19-Jul'19

Research Intern, Media and Data Science Research Lab

Adobe Systems, Noida

Introduction: Visual compatibility prediction refers to the task of determining if a set of clothing items (an outfit) go well together. There are three modalities involved in modeling an outfit: category (jeans, shirt, shoes, etc.) of individual clothing items, the context of an item (a set of other items it is compatible with), and the fashion style of an outfit. We propose a unified framework combining all of these modalities.

- Proposed a Machine Learning framework that outperforms the current state-of-the-art model by **10%** points in quantitatively measuring the compatibility of a set of clothing items using only visual cues in a fill-in-the-blank test
- Introduced a category conditioned **Graph Convolution Network** to model the category and context of the items
- Developed an Attention-based Autoencoder for clustering the outfits in 6 clusters based on their fashion styles
- Used Reinforcement Learning techniques to combine the two measures further improve the accuracy by **1%**

### Adaptive Mode Estimator for Continuous Distributions | Master's Thesis

Jan'20-Sep'20

Guide: Prof. Nikhil Karamchandani, Electrical Engineering

IIT Bombay

Introduction: Motivated by the mode estimation problem of an unknown multivariate probability density function, we study the problem of identifying the point with the minimum  $k^{th}$  nearest neighbor distance for a given dataset of  $n$  points. We study the case where the pairwise distances are apriori unknown, but we have access to an oracle which we can query to get noisy information about the distance between any pair of points.

- Designed a 2-layer sequential multi-armed bandit algorithm to find the point with minimum  $k$ -NN distance
- Analyzed the performance of the proposed algorithm for two types of oracles: (i) oracle returns distance of two points along a random dimension, and (ii) oracle adds a sub-Gaussian noise to the true distance of two points
- Proposed an **Information Theoretically** optimal algorithm that estimates the  $k^{th}$  nearest neighbor of a point
- Showcased optimality of the algorithm by finding its upper and lower bounds and proving they are of same order

## Bandits with Incomplete Control | Master's Thesis

Oct'20-Present

Guides: Prof. Nikhil Karamchandani & Prof. Jayakrishnan Nair, Electrical Engineering

IIT Bombay

Introduction: In the traditional multi-armed bandit setting, we have the choice to pull any arm. We introduce a new paradigm in which all the arms are divided into multiple boxes, and we only have the freedom to poll a box. The box will then pull an arm in it, depending on an unknown underlying distribution.

- Proposed an algorithm to find the best arm, and found a theoretical upper bound on the no. of box polls required
- Developing algorithms for finding boxes with highest expected reward, minimum variance, and highest mode reward

## Reduced Feedback Techniques for Kerdock MIMO-OFDM Precoders

Jan'20-Jul'20

Guide: Prof. Kumar Appaiah, Electrical Engineering

IIT Bombay

Introduction: In a MIMO system, precoder matrices are required to ensure optimal directivity at the transmitter. The receiver needs to send feedback data to the transmitter to ensure it uses optimal precoders. Kerdock codes are a new type of codebook design which are more efficient than traditional codebooks.

- Extended the use of Kerdock codes for MIMO-OFDM systems for lower storage and computational requirements
- Implemented clustering and **geodesic** based interpolation techniques on MATLAB for compressing feedback data

## INTERNSHIP

### Software Development Intern | OkCredit

May'18-Jul'18

Developed an in-house app analytics service for OkCredit, a startup which provides a mobile-based digital ledger

- Designed an infrastructure to collect the user interactions of 10k+ users from a mobile app for product analytics
  - Built a stateless server in Google Go to store data in a Cassandra database and transfer it daily to Amazon S3
  - Created an Android Library to store user interaction data locally on the mobile phone and send it to the server
- Incorporated Google Sign-In as an ID provider in an OAuth 2.0 protocol based authentication service in Google Go
- Devised and performed unit & load tests of REST APIs to calculate their maximum load as a function of resources

## SCHOLASTIC ACHIEVEMENTS

- Awarded the **Institute Academic Prize** for standing 1<sup>st</sup> out of 70+ students for the academic year 2019-20
- Scored a Semester Point Index (SPI) of **10/10** in the 7<sup>th</sup> and 8<sup>th</sup> semesters '19,'20
- Awarded **AP Grade** (Advanced Performance) for stellar academic performance in two courses: *Network Theory* under Prof. M. Gopalakrishnan and *Markov Chains & Queuing Systems* under Prof. P. Chaporkar '18,'19
- Secured **All India Rank** of **368** out of 150k candidates appearing in the **JEE Advanced** examination '16
- Recipient of the prestigious **KVPY** (among **top 2%** out of **50k+** candidates) Fellowship by Govt. of India '15

## COURSE PROJECTS

### Markov Chains Monte Carlo Convolutional Decoder

Spring'19

Markov Chains & Queuing Systems: Prof. Prasanna Chaporkar, Electrical Engineering

IIT Bombay

- Proposed a convolutional decoder that estimates the uncoded bits using the Markov Chain Monte Carlo simulations
- Implemented the decoder on MATLAB and achieved error rates comparable to the current state-of-the-art decoders

### Coronary Heart Disease Detection

Fall'19

Machine Learning and Data Mining: Prof. Morten Mørup, DTU Compute Technical University of Denmark

- Achieved an accuracy of 75% in identifying Coronary Heart Disease in patients using regularized logistic regression
- Employed association rule mining to find 13 associations in patient's attributes with the confidence of at least 80%

### Texture Synthesis by Non-Parametric Sampling

Fall'18

Digital Image Processing: Prof. Ajit Rajwade, Computer Science Engineering

IIT Bombay

- Synthesized a new texture from an initial seed on MATLAB, which was used for hole filling and image expansion
- Modeled the image as a Markov Random Field (MRF) to find the probability distribution of a pixel to be predicted

### Pipelined RISC Processor Design

Fall'18

Microprocessors: Prof. Virendra Singh, Electrical Engineering

IIT Bombay

- Designed a 16-bit, 6-stage pipelined RISC microprocessor based on a Turing-complete Instruction Set Architecture
- Simulated the design in VHDL and verified the working with RTL followed by flashing the code on an FPGA board

## Digitally Programmable Analog Computer

Spring'19

Electronic Design Lab: Prof. Mukul Chandorkar, Electrical Engineering

IIT Bombay

- Proposed a hybrid system of analog and digital modules which solves non-linear differential equations in 8 variables
- Designed an analog module using integrators and interfaced it with a micro-controller to compute non-linearities
- Implemented the system on a two-layered printed circuit board with on-board power management using EagleCad

## Risk Analysis and Portfolio Optimization

Fall'19

Financial Engineering: Prof. Nina Lange, DTU Management

Technical University of Denmark

- Designed the global minimum variance and tangent portfolio consisting of 8 stocks with and without short-selling
- Attained a return of 60.88% with a risk of 0.42 and a Sharpe ratio of 1.42 for the tangent portfolio with shorting

## OTHER TECHNICAL PROJECTS

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### Electrical Subsystem Leader, Advitiy | IITB Student Satellite Program

Feb'17-Mar'19

Advitiy is the second student satellite of IIT Bombay, fully developed and researched by students of IIT Bombay

- Spearheaded a **10** membered inter-disciplinary team consisting of two subdivisions: Power and On-Board Computer
- Contributed to [Satellite 101 Wiki](#), a compilation of the knowledge of the satellite project gaining **100k+** views
- Finalized the micro-controller for the On-Board Computer by critically analyzing various parameters and constraints

### Technologies for Soldier Support | Inter IIT Technical Meet

Dec'17-Jan'18

Part of an 8 member team that represented IIT Bombay in the Inter IIT Technical Meet held at IIT Madras

- Fabricated a smart glove consisting of five flex sensors and an accelerometer for detecting soldier's hand gestures
- Built a headband to monitor soldier's critical physiological parameters such as heartbeat, temperature, and head impact force using optical pulse sensor, temperature sensor and accelerometer, for providing faster First Aid

## KEY COURSES UNDERTAKEN

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### Computer Science

Advanced Machine Learning, Digital Image Processing, Design and Analysis of Algorithms<sup>†</sup>, Machine Learning and Data Mining, Operating Systems, Data Structures and Algorithms, Computer Networks, Network Security

### Electrical Engineering

Acoustic Signal Processing, Mobile Communications, Non Linear Dynamics, Signals and Systems, Analog and Digital Systems, Microprocessors

### Mathematics and Statistics

Markov Chains and Queuing Systems, Data Analysis and Interpretation, Probability and Random Processes, Matrix Computations, Linear Algebra

<sup>†</sup> To be completed by Dec'20

## TECHNICAL SKILLS

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### Programming Languages

Python, C++, Google Go, SQL, VHDL, Embedded C, Java

### Other Softwares and Modules

TensorFlow, Pytorch, Android Studio, OpenCV, NumPy, Pandas

## TEACHING EXPERIENCE

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### Teaching Assistant | IIT Bombay

MA 207 : Differential Equations 2 under Prof. Swapneel Mahajan, Department of Mathematics

Spring'19

EE 325 : Probability & Random Processes under Prof. Nikhil Karamchandani, Electrical Engineering

Fall'20

- Upskilled the performance of **150+** students by collaborating with the instructor and conducting weekly tutorials
- Helped students in the online semester due to the COVID-19 outbreak by conducting remote doubt clearing sessions

### Volunteer | Educational Outreach, National Service Scheme, IIT Bombay

Aug'16-Apr'17

NSS is a 3.8 million strong body that aims to bring about positive social change through numerous initiatives

- Taught English to college kitchen staff in their free time as a part of the **Adult Literacy Program**
- Volunteered in **NGO Vidya** for tutoring financially and socially underprivileged children in Mathematics and Science

## EXTRA CURRICULAR ACTIVITIES

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- Social Work** : Assisted in setting up 150 Free Diabetes screening camps to spread awareness among 0.1M people
- Travelling** : Backpacked across 15 European countries and 25+ cities in 4 months on a shoestring budget
- Adventures** : Skiing in Zakopane, Poland; Trekking on Mt.Ulriken in Bergen, Norway; Mountaineering in J&K